

GENETIC VARIABILITY AND ASSOCIATION OF COMPONENT CHARACTERS FOR FRUIT YIELD IN PAPAYA (*Carica papaya* L.)

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Abstract

Genetic variability and character association studies was carried out in 44 genotypes. Wide range of variability was observed in yield (1.46 to 17.50 kg/plant), number of nodes to first flower (29.66 to 76.66), leaf length (31.00 to 53.66 cm), plant height (81.66 to 191.0cm), east-west spread (126.6 to 206.66), fruit length (12.36 to 21.56 cm) fruit width (8.33 to 16.30 cm), number of fruits/plant (2.66 to 19.33) and total sugar (6.20 to 12.8). The co-efficient of variation ranged from 8.78 to 27.99 in pulp thickness and acidity respectively. High heritability of 94.8% was found in character number of fruits per plant. All phenotypic coefficient of variation was higher than that of genotypic coefficient of variation. The yield was significantly correlated with fruit length (0.475). It can be concluded on the basis of path analysis in the present investigation that the character like total sugar content, fruit width and number of fruits per plant has high positive direct effect on yield/plant at genotypic level which suggests the significance of these characters while selection in papaya breeding programme. Mean fruit weight showed negative direct effect on yield of papaya/plant which clearly indicated that number of fruits per plant is more important rather than individual fruit weight.

INTRODUCTION

The papaya (*Carica papaya* L.) is one of the most important fruit crops grown in India in which improvement has been achieved through breeding and selection. In Papaya, yield is the most important character for selection and breeding of desirable types. Being a highly cross pollinated crop, wide range of variation in quantitative characters provides the basis for selection in any fruit traits which facilitates the choice of suitable parents in the crop improvement programme. Correlations are helpful in determining the components of complex traits like yield which is dependent on several component characters (Decenta and Garcia, 1992). This type of analysis only provides information in the relationship and sometimes information obtained is misleading with respect to the identification of yield components. In perennial fruit crops like papaya, the heterozygous nature of the plant is a moderate factor in the breeding programme. In order to understand causal fac-

tors of the correlation among traits, the estimate of the direct and indirect effect computed through path analysis to determine direct and indirect contribution to various characters towards yield are very useful. Reports on correlation among different characters and information on direct and indirect effect of different character on papaya is very meager. Therefore, present study of relationship between yield, direct and indirect effect was proposed with the aim of gathering information which could be fruitful for further papaya improvement programme.

MATERIALS AND METHODS

The present experimental material for this study comprised of 44 true breeding accessions of papaya, of which CO-2, CO-3, CO-4, CO-7, Washington, Sunrise Solo, Thailand, Singapore, Nigeria, Namkum, Ranchi, Delhi, Bangalore and Tata selection were commercially important. These accessions, in the 3-4 generation were grown in a randomized block design with three replications at the Germplasm block of Horticult-

ture and Agro-Forestry Research Programme, ICAR complex for eastern region, Ranchi. This area is situated around 620 m above mean sea level. and at 23°25' N latitude and 85°20' E longitude with average annual rainfall of 80-140 cm. Data had been recorded from 44 papaya germplasm with a sample of 3 plants in each replication, in respect of yield, vegetative growth and fruit physico-chemical characters. Coefficient of variation, heritability (broad sense) and genetic advance were worked out by following the method given by Burton and De Vane (1953) and Johnson *et al.*, (1955). The phenotypic and genotypic coefficient of correlation were computed as suggested by Al-Jibouri *et al.*, (1958) and the path coefficient analysis of various traits was done following the method of Dewey and Lu (1959).

RESULTS AND DISCUSSION

The analysis of variance indicated that high and significant differences were observed for all attributes viz., yield/plant, number of nodes to first flower, height of the first fruit, leaf length, leaf width, length of petioles, trunk girth, plant height, north-south spread, east-west spread, fruit length, fruit width, number of fruits/plant, fruit weight, pulp thickness, central cavity diameter, T.S.S., acidity and total sugar percentage. The range of general mean, coefficient of variation and F-value of genotypes have been presented in Table 1. The result indicated that a wide range of variability was observed in yield (1.46 to 17.50 kg/plant), number of nodes to first flower (29.66 to 76.66), leaf length (31.00 to 53.66 cm), plant height (81.66 to 191.00 cm), east-west spread (126.6 to 206.66 cm), fruit length (12.36 to 21.56 cm), fruit width (8.33 to 16.30 cm), number of fruits/plant (2.66 to 19.33) and total sugar (6.20 to 12.8). The coefficient of variation ranged from 8.78 to 27.99 in pulp thickness and acidity, respectively.

The result reveals that phenotypic coefficient of variation for all the characters

was higher than the genotypic coefficient of variation (Table 1). However for the number of fruits/plant, fruit weight, pulp thickness, central cavity, diameter and T.S.S. differences were minimal. The magnitude of heritability indicated the reliability of the genotype which they can be identified with their phenotypic expression. The heritability ranged from 25.8 to 94.8 in leaf, length and number of fruits/plant, high heritability was also observed for yield per plant. Fruit weight and central cavity diameter the genetic advanced (GA) over mean was maximum for north-south spread and east-west spread and plant height. Selection efficiency is related to manipulate heritability and genetic advanced as reported by Johnson *et al.*, (1955) and Iyer *et al.*, (1993). High heritability coupled with high genetic advanced and GA as percentage of mean will help in expressing the selection pressure for crop improvement. Yield/plant, number of fruits/plant, fruit width had high heritability and high percentage of GA over mean hangs these characters can be considered to be governed by additive gene action. The characters like number of nodes, plant height, plant spread (north-south, east-west), fruit length, fruit width, pulp-thickness central cavity diameter, T.S.S. and total sugar had high to moderate heritability and low genetic advance indicating higher environmental influence on these characters. Hence improvement of such traits will need high selection intensity.

Correlation

The yield/plant had high and significant positive correlation with fruit weight, pulp thickness and total sugar percentage (Table 2). Length of petiole (0.668) and trunk girth (0.749) was significantly correlated with plant height. Similar findings have also been reported by Dwivedi *et al.*, (1999). The yield was also significantly correlated with number of fruits/plant (0.585). Fruit weight (0.475) high correlation was observed between fruit weight and fruit width (0.724). The fruit width was significantly correlated

Table 1. The range, general mean, CV. and heritability of 44 genotypes of papaya

Characters	Range	Mean	C.V.%	Component of variance			PCV (%)	GCV (%)	H(%)	GA (% of mean)
				σ^2C	σ^2E	σ^2P				
Yield/plant kg	1.46-17.50	7.200	23.279	12.983	2.809	15.792	55.194	50.045	82.2	93.47
No. of nodes to first flower	29.66-76.66	42.409	14.746	62.611	39.109	101.720	23.782	18.658	61.5	30.15
Height of the fruit	48.66-117.00	80.409	18.170	196.723	226.350	423.074	25.580	17.443	46.5	25.50
Leaf length (cm)	31.00-53.66	41.167	18.009	19.071	54.963	74.034	20.901	10.608	25.8	11.09
Leaf width (cm)	29.00-55.00	42.401	14.568	26.643	38.158	64.801	18.985	12.173	41.1	14.57
Length of petiole (cm)	27.66-58.33	46.712	16.820	28.475	61.730	90.205	20.332	11.424	31.6	15.22
Trunk girth (cm)	10.66-26.33	20.576	13.689	4.634	7.933	12.567	17.229	10.462	36.9	13.08
Plant height (cm)	81.66-191.00	133.462	14.152	378.764	356.738	735.502	20.320	14.582	51.5	21.55
Plant spread (N-S)	98.00-186.66	151.947	10.935	422.064	276.052	698.116	17.389	13.521	60.4	21.65
Plant spread (E-W)	126.6-206.66	152.538	12.014	418.410	335.852	754.262	18.005	13.410	55.5	20.57
Fruit length (cm)	12.36-21.56	16.042	10.483	4.289	2.828	7.107	16.619	12.895	60.2	20.61
Fruit width (cm)	8.33-16.30	11.383	9.400	2.441	1.145	3.586	16.636	13.726	68.1	23.33
No. of fruit plant	2.66-19.33	8.757	9.845	13.671	0.743	14.415	43.353	42.220	94.8	84.70
Fruit weight (kg)	0.41-2.50	0.863	16.822	0.160	0.021	0.181	49.324	46.367	88.4	89.80
Pulp thickness	1.90-2.90	2.395	8.786	0.060	0.044	0.104	13.499	10.248	57.6	16.03
Central cavity	4.10-10.50	6.533	8.833	1.894	0.333	2.226	22.839	21.061	85.0	40.01
T.S.S. (°brix)	7.20-13.10	9.385	9.387	1.631	0.776	2.407	16.532	13.609	67.8	23.07
Acidity (%)	0.06-0.16	0.120	27.993	0.0004	0.001	0.001	32.638	16.782	26.4	11.5
Total sugar	6.20-12.80	8.579	11.996	1.434	1.059	2.493	18.404	13.957	57.5	21.79

Table 2. Correlation among 19 traits in papaya

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19			
	yield/ plant	No. of nodes	Ht. at first fruit	Leaf length	leaf width	Length of petiole	Trunk girth	Plant height	Plant spread (N-S)	Plant spread (N-E)	Fruit length	Fruit width	Fruit plant	No. of Fruit fruits/ plant	Pulp weight/thick ness	CentralTSS cavity	Acidity	Total sugar				
1. G.	1.00	-0.053	-0.31	0.222	0.293	0.319	-0.002	0.159	0.102	0.171	0.415	0.530	0.585	0.475	0.323	0.285	0.107	-0.437	0.115			
P.	1.00	-0.042	-0.17	0.101	0.203	0.235	0.050	0.129	0.088	0.107	0.379	0.472	0.503	0.515	0.264	0.246	0.072	-0.183	0.057			
G.	1.00	0.682	-0.023	-0.159	-0.275	0.120	0.191	-0.237	-0.204	-0.204	0.172	0.270	-0.112	0.196	-0.018	0.239	-0.088	0.206	-0.278			
P.	1.00	0.611	-0.036	-0.197	-0.108	0.122	0.228	-0.111	-0.089	0.075	0.092	0.415	-0.094	0.114	0.012	0.127	-0.085	0.026	-0.183			
G.	1.00	1.00	0.220	0.081	0.292	0.660	0.674	0.191	0.178	0.355	0.415	0.141	-0.173	0.199	0.102	0.368	0.163	0.234	0.070			
P.	1.00	1.00	0.097	0.114	0.225	0.443	0.554	0.080	0.010	0.177	0.141	0.030	-0.120	0.084	0.051	0.211	0.088	0.019	-0.065			
G.	1.00	1.00	0.997	0.759	0.522	0.622	0.358	0.522	0.399	0.355	0.030	0.042	0.395	0.239	-0.106	0.210	-0.473	0.220	-0.135			
P.	1.00	1.00	1.00	0.727	0.586	0.243	0.185	0.383	0.357	0.049	0.031	0.031	-0.019	0.181	0.050	-0.035	0.149	-0.129	0.135			
G.	1.00	1.00	1.00	0.833	0.389	0.347	0.678	0.678	0.658	0.256	0.175	0.175	-0.044	0.404	0.211	0.038	0.311	0.570	0.282			
P.	1.00	1.00	1.00	0.668	0.255	0.514	0.452	0.514	0.452	0.162	0.137	0.137	-0.036	0.260	0.143	-0.007	0.243	0.248	0.218			
G.	1.00	1.00	1.00	1.00	0.749	0.598	0.578	0.578	0.557	0.370	0.240	0.240	-0.087	0.244	0.227	0.087	0.655	-0.729	0.619			
P.	1.00	1.00	1.00	1.00	0.386	0.370	0.468	0.468	0.157	0.208	0.161	0.161	-0.073	0.164	0.178	0.048	0.325	-0.221	0.288			
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.849	0.612	0.696	0.138	0.194	-0.063	0.230	0.075	0.339	0.434	-0.080	0.440			
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.618	0.254	0.266	0.197	0.115	-0.116	0.286	0.338	0.447	0.387	-0.138	0.287			
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.499	0.499	0.545	0.411	0.418	-0.083	0.169	0.160	0.308	0.231	-0.012	0.096			
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.270	0.270	0.290	0.240	0.223	-0.010	-0.021	0.032	-0.078	0.237	-0.352	0.11			
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.995	0.124	-0.046	0.010	-0.021	0.032	-0.078	0.164	-0.258	0.140			
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.906	0.047	-0.025	0.013	-0.006	0.029	-0.076	0.204	-0.369	0.094			
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.205	0.006	0.050	0.019	0.026	-0.026	0.101	-0.234	0.106			
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.041	-0.007	-0.034	0.002	0.011	0.026	0.342	-0.521	0.086			
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.536	-0.160	0.653	0.177	4.756	0.342	-0.521	0.086			
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.452	-0.128	0.551	0.201	0.325	0.232	-0.197	0.017			
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.089	0.724	0.694	0.890	0.419	-0.248	0.272			
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.073	0.637	0.558	0.794	0.335	-0.078	0.186			
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.062	0.001	-0.210	-0.286	0.007	-248			
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.066	0.002	-0.183	-0.224	-0.014	-0.161			
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.350	0.559	0.222	-0.337	0.117	-0.161			
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.300	0.502	0.166	-0.130	0.069	-0.161			
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.537	0.444	-0.107	0.337		
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.339	0.289	-0.074	0.183		
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.440	-0.051	0.289		
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.336	0.032	0.215		
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.486	0.875		
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.327	0.767		
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.421		
P.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.299	
G.	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table-3. Showing the partitioning of yield contributing attributes into direct and indirect effect

	No. of nodes to first flower	Ht. of first flower	Leaf length	Leaf width	Leaf petiole width	Trunk girth	Plant height	Plant spread (N-S)	Plant spread (N-E)	Fruit length	Fruit width	No. of fruits/plant	Fruit weight/thickness	Plant acidity	Total sugar				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
No. of nodes to first flower	-0.137	0.169	0.001	-0.065	0.105	-	0.017	0.035	-0.048	0.057	0.207	-0.078	-0.027	0.003	-0.051	0.048	-0.033	-	-0.053
Height of first fruit	-0.094	0.249	0.011	0.033	-0.112	0.035	0.062	-0.028	0.042	0.119	0.319	-0.120	-0.028	-0.018	-0.078	-	-0.037	-	-0.031
Fruit length	0.003	0.055	0.052	0.405	-0.290	0.182	0.033	-0.077	0.094	0.119	0.023	0.029	-0.056	-0.042	0.023	-	0.076	-	0.178
Leaf width	0.022	0.020	0.052	0.406	-0.319	0.114	0.032	-0.099	0.154	0.085	0.134	-0.031	-0.057	-0.037	-0.008	-	0.091	-	0.235
Length of petiole	0.038	0.073	0.039	0.338	-0.383	0.219	0.055	-0.085	0.131	0.124	0.184	-0.060	-0.034	-0.039	-0.018	-	0.117	-	0.499
Trunk girth	-0.016	0.154	0.033	0.158	-0.286	0.293	0.078	0.089	0.164	0.046	0.149	-0.044	-0.032	-0.013	-0.072	-	0.238	-	0.355
Plant ht.	-0.026	0.168	0.019	0.141	-0.229	0.249	0.046	-0.147	0.234	0.041	-0.036	0.007	0.003	-0.006	0.017	-	0.056	-	0.089
Plant spread (N-S)	0.033	0.047	0.027	0.275	-0.221	0.179	0.051	-0.146	0.235	0.068	-0.005	0.035	-0.003	-0.004	0.016	-	0.130	-	0.075
Plant spread (E-W)	-0.024	0.088	0.021	0.267	-0.213	0.204	0.038	-0.018	0.048	0.334	0.411	-0.111	0.092	-0.031	-0.097	-	0.112	-	0.070
Fruit length	-0.037	0.103	0.001	0.104	-0.142	0.040	0.038	0.007	-0.001	0.179	0.767	-0.062	-0.102	-0.122	-0.189	-	0.230	-	0.219
Fruit weight	0.015	0.043	0.002	0.071	-0.092	0.057	0.011	-0.001	0.012	-0.053	-0.068	0.695	0.009	-0.002	0.045	-	0.157	-	0.094
No. of fruits/plant	-0.027	0.050	0.021	-0.018	0.033	0.018	0.026	0.003	0.004	0.218	0.556	-0.043	-0.141	-0.161	-0.119	-	0.054	-	0.585
Fruit weight	0.002	0.025	0.021	0.086	-0.087	0.067	0.031	-0.005	0.006	0.059	0.532	0.001	-0.049	-0.176	-0.114	-	0.243	-	0.200
Pulp thickness	-0.033	0.092	0.005	0.015	-0.033	0.099	0.041	0.011	-0.018	0.152	0.683	-0.146	-0.079	-0.094	-0.213	-	0.241	-	0.094
Central cavity	0.012	0.040	0.011	0.126	-0.251	0.127	0.035	-0.035	0.048	0.114	0.321	-0.199	-0.031	-0.078	-0.094	-	0.549	-	0.706
T.S.S.	-0.028	0.058	0.025	-0.231	0.279	0.023	0.013	0.051	-0.087	-0.174	-0.190	0.005	0.047	0.019	0.011	-	0.267	-	0.339
Acidity	0.038	0.017	0.011	0.118	-0.237	0.129	0.026	-0.016	0.022	0.029	0.208	-0.173	-0.016	-0.059	-0.061	-	0.480	-	0.806
Total sugar	0.038	0.017	0.011	0.118	-0.237	0.129	0.026	-0.016	0.022	0.029	0.208	-0.173	-0.016	-0.059	-0.061	-	0.480	-	0.806

Residual effect = 0.3209902

with pulp thickness (0.694) as well as cavity diameter (0.890). Hence, a higher fruit weight can be attributed to a higher fruit width as a result of higher pulp thickness as well as cavity diameter. The titrable acidity was significantly and negatively correlated to T.S.S. (-0.486) and total sugar (-0.421). The negative correlation can be attributed to acid respiration during ripening process. Number of nodes to the first flower had significant and positive association with plant height. Similarly yield had high and significant positive association with fruit length (0.415) and width (0.530).

Path analysis

The yield in papaya is a function of a number of contributing plant characters. Estimation of direct and indirect effects of these characters helps in fixing up of selection of criteria for yield in papaya. In the present investigation the total sugar percent (0.806) had the maximum direct positive effect on yield followed by fruit width (0.767) (Table 3). The fruit weight did not have any positive direct effect on yield (-0.141) although it had the maximum correlation on yield (0.585). Hence, fruit weight indirectly contributed towards yield through its effect on fruit width and fruit length. The number of fruits/plant also had significant direct effect on yield (0.695). This is an indication of lack of compensatory correlation between fruit number and fruit weight in papaya. The leaf width also had significant positive direct effect on yield (0.406). It clearly indicated that a wider leaf contributed towards yield through its effect on the leaf, photosynthetic area. Other characters

like height of first, fruit spread (east-west), fruit length showed direct positive effect on yield indicating their suitability as selection indicators for yield in papaya.

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